

Syllabus for Weizmann course: Earth System Science 101

Instructor: Dr. Warren Wiscombe (NASA Goddard Space Flight Center)

This course aims for an understanding of Earth System Science and the interconnection of its various “spheres” (atmosphere, hydrosphere, etc.) by adopting the view that “the microcosm mirrors the macrocosm”. We shall study a small set of microcosms, each residing primarily in one sphere, but substantially involving at least one other sphere, in order to illustrate the kinds of coupling that can occur and gain a greater appreciation of the complexity of even the smallest Earth System Science phenomenon.

There will be two lectures and one discussion period per week. The discussion period will include questions from the students on the lectures, informal quizzes, homework discussion, and an occasional Socratic dialog about an Earth System subject. The course will be graded as follows: midterm exam (25%), final exam (35%), homework (20%), and, working in teams of two, a mini-research project on an Earth System Science phenomenon not covered in class (20%).

Lecture 1: The spheres: atmo, hydro, chemo, cryo, bio, geo, anthro, and their coupling

Lecture 2: How do we measure the Earth System? In situ and remote measurements

Lecture 3: The DOE-ARM Program: an example combining in situ and remote sensing

Lecture 4: The NASA EOS Program: an example of satellite-based remote sensing

Lecture 5: How do we measure the Earth System? Paleoclimate proxies

Lecture 6: The climate of the last billion years and the role of life and of greenhouse gases

Lecture 7: The climate of the last complete glacial cycle and the role of orbital forcing

Lecture 8: The climate since the end of the last Ice Age (the last 15,000 years)

Lecture 9: How do we model the Earth System? simple models (energy balance, radiative-convective, box)

Lecture 10: How do we model the Earth System? complex models (GCMs, global cloud-resolving, large-eddy, regional/mesoscale); predictability, chaos, and “tipping points”

Atmosphere segment:

Lecture 11: Mount Pinatubo and global cooling

Lecture 12: Aerosol effect on clouds and precipitation

Hydrosphere segment:

Lecture 13: Sea level change – fact and fiction

Lecture 14: Ocean acidification due to CO₂ rise, and coral reefs

Midterm Exam

Biosphere segment:

Lecture 15: Tropical deforestation and biomass burning

Lecture 16: The Great North American Megafaunal Extinction

Chemosphere segment:

Lecture 17: The Ozone Hole

Lecture 18: Vegetation role in Carbon Cycle

Cryosphere segment:

Lecture 19: Arctic sea ice retreat and global warming

Lecture 20: Melting of Greenland and how we measure it

Hand in mini-research project

Geosphere segment:

Lecture 21: Fossil fuels and Peak Oil

Lecture 22: Mega-volcanism of the past: Toba, Yellowstone, Deccan Traps

Anthroposphere segment:

Lecture 23: Global warming: history

Lecture 24: Global warming: the current state of affairs

Lecture 25: Geo-Engineering

Lecture 26: Overpopulation, economics, and exponential growth

Lecture 27: The extinction of the dinosaurs 65M years ago by an asteroid impact, a problem involving every aspect of the Earth System

Final Exam